PATENT SPECIFICATION

DRAWINGS ATTACHED

981,964

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COMPLETE SPECIFICATION

Improvements in Variable Capacity Gear Pumps

We, WALTER REINERS and GEORG WIGGERMANN, both German Nationals, of 54 Peter - Nonnenmuhlen - Allee, Munchen-Gladbach, Rheinland, Germany, and 10 Spitzgartenweg, Kressbronn, Germany respectively, trading together as FIRMA REINERS AND WIGGERMANN, Getriebe - und Maschinenbau, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to variable capacity gear pumps and to an improvement in or modification of the gear pump arrangement described and claimed in Patent Specification No. 882,248, referred to hereinafter as the parent Specification.

The gear pump arrangement claimed in claim 1 of the parent Specification comprises two two-wheel gear pumps having a single drive and the output from each of which is infinitely adjustable, each pump being connected to common supply and discharge conduits, and a change-over device connected between one of the pumps and the said conduits by means of which the direction of flow through said one pump is reversible, enabling both pumps to discharge simultaneously in the same direction or in opposite directions. A similar change-over device may be connected between the other pump and the supply and discharge conduits, this arrangement enabling the direction of flow in the conduits to be reversed. The output from each pump may be varied by means of an individual mechanical adjusting member, the two adjusting members and the two change-over devices being operable in the same direction or in opposite directions.

In the gear pump arrangement disclosed in the parent Specification it is necessary, in order to provide the largest possible regulating range, to utilize fully the permissible variation of distance in the case of evolute teeth and to shape the teeth so that the greatest possible range of adjustment in the inter-axis wheel spacing is provided. For this purpose it is important to select the addendum circle diameter, the pitch circle diameter and also the number of teeth in such fashion that:

1) with the minimum inter-axis wheel spacing the addendum circles intersect the then prevailing lines of action at points which lie adjacent the points of contact of said lines of action with the pitch circles, or coincide with these points;
2) in the case of maximum inter-axis wheel spacing the degree of overlap of the teeth still has a value of at least 1; and
3) the tips of the teeth are somewhat pointed, the ratio between maximum tooth thickness and tip thickness (in each case in accurate measurement) being between about 6 and 8.

In the case of evolute teeth constructed according to these conditions, however, the teeth acquire a form which differs from the usual tooth forms due to the great tooth height and a correspondingly great radial depth of gap. The deep tooth gap, which is relatively narrow, involves certain difficulties in production and it is an object of the present invention to avoid such difficulties.

According to the invention there is provided an improvement in or modification of the gear pump arrangement claimed in claim 1 of Specification No. 882,248, wherein the gear teeth have an addendum equal to not less than 1.25×module, and wherein grinding of the tooth flanks is limited to that

[*Price 4s. 6d.*]

tooth part between the pitch and addendum circles.

The invention is illustrated by way of example in the single Figure of the accompanying drawing, which is a fragmentary side view of one of the gear pump wheels.

The drawing shows four teeth designated by the references 1*a*, 1*b*, 1*c* and 1*d* and the three tooth gaps disposed therebetween. The effective evolute part of the tooth flanks extending between the pitch circle *dg* and the addendum circle *dk* and having the height H*k* is shaped similarly in all four teeth and needs no further particular mention. The tooth gap between the teeth 1*a* and 1*b* corresponds in shape to the usual form, wherein the evolute flanks merge at the pitch circle into straight lines extending radially of the wheel and enclosing the angle δ_1, and finally merging through rounded portions into the root circle. In order to achieve the required sealing, exact mutual rolling of the flanks of the meshing teeth must occur, and flank grinding of the teeth is necessary for this purpose. It is usual to cut the entire tooth flank including the tooth root by means of a milling cutter providing a certain grinding allowance. This is indicated at the left-hand side of the tooth gap A between the teeth 1*a* and 1*b* by a chain line, while the gap half illustrated on right-hand side of the tooth gap corresponds to the final ground tooth form.

The relatively great radial extent of the narrow tooth gap is unsuitable either for hob-type milling or for grinding of the tooth flanks in a rounding process and the tooth gaps must instead be produced by means of the time-wasting and therefore expensive profile milling or profile grinding process. The large area of contact between the grinding wheel and the work piece occurring during grinding in the region of tooth root produces very unpleasant lateral pressures upon the work piece and the generation of considerable heat, which leads to surface cracks on the work-piece. If, both for the lateral support of the grinding wheel and in order to limit the grinding time, the grinding operation is carried out by means of a grinding wheel working at both sides on the tooth flanks the further disadvantage arises that the radially extending grinding wheel part or the part grinding the gap in the region of the tooth root, even in the case of a minimum removal of material by wear and trueing, nevertheless results in a substantial reduction in diameter, and the consequence thus is a high consumption of grinding wheels. This will be apparent from the profile of the grinding wheel indicated in hatched form in the gap between teeth 1*a* and 1*b*. The grinding wheel side disposed to the left-hand side of the tooth gap is here shown in the position at the commencement of the grinding operation and the grinding wheel side illustrated to the right-hand side of the tooth gap and also shown with hatched outline form is in the position at the end of the grinding operation.

By means of the invention, the tooth flank grinding is restricted to the flank parts between the addendum circle *dk* and the pitch circle *dg*, and the non-active gap part, commencing in the region of the pitch circle *dg*, being brought to the final dimensions in a machining operation preceding the grinding.

Such a measure is permissible firstly in the kinematic respect, since flank parts disposed inwardly of the pitch circle never participate in the flank contact. On the other hand, however, for the initially indicated reasons, in order to achieve a large delivery volume such a deep engagement of the meshing teeth is necessary that the tooth flanks practically must be satisfactory as far as the pitch circle. If the grinding is omitted at the tooth root part, the radial root flanks, already machined to final dimensions, extend so far that the final grinding extends from the tooth tips only as far as the point *p*. In the preceding milling and hardening operations the occurence of graduation differences must always be expected and the termination of the final grinding outwardly of the pitch circle then produces undesired inaccuracies in the transition from the ground to the unground flank parts.

In order to improve these conditions and as shown for the tooth gap B between the teeth 1*c* and 1*d*, there is imparted to the tooth gap part inwardly of the pitch circle *dg* a shape which is formed substantially by two parallel faces having the spacing α and at the bottom of the gap a large rounded surface to which the dedendum circle *df* is tangential. The distance α is equal to, or slightly greater than, the spacing of the adjacent points of intersection of the evolutes with the pitch circle, so that the points *p* at which the final grinding terminates and which correspond to the intersection of the two parallel faces with the flank portions extending from the tooth tips are brought much closer to the pitch circle due to the resulting flank curvature at these points. This has the advantage of a significantly reduced sensitivity in the grinding operation with regard to the above-mentioned graduation differences. A further advantage is that it is possible to effect the flank grinding by a rolling operation, since due to the bend produced by the tooth flank in the region of the pitch circle the grinding wheel, especially when the distance α is made a little larger than the spacing of the evolute intersection points with the pitch circle, has a certain termination and the grinding wheel periphery must project only by a small amount into the pre-milled tooth gap part (see the tooth gap existing between the teeth 1*c* and 1*b* and the grinding wheel profile illustrated by

hatching). Here again the left-hand side of the gap and the grinding wheel are illustrated at the commencement of grinding and the right-hand side of the gap and the grinding wheel at the end of the grinding operation.

Such a construction of the tooth gap still has the disadvantage that the angle δ_2 of the grinding wheel profile can only be very acute and accordingly here again the wear on the grinding wheel in grinding and trueing results in relatively great losses of diameter. By way of explanation it should here be mentioned that a variation x of the grinding wheel in directions normal to the oblique grinding faces of the grinding wheel caused by wear or trueing of the wheel with a diamond always results in a reduction of grinding wheel diameter of $\Delta D = 2x/\sin\delta$, where δ is the angle formed by the oblique faces of the grinding wheel. Accordingly, in the case of the grinding wheel indicated between the teeth 1*c*, 1*d*, wearing or trueing of the grinding wheel by x=0.1 mm. corresponds to a reduction in diameter of about 0.4 mm, whereby considerable grinding wheel expenses are still incurred.

The development of the tooth gap form B, beside the stated advantages, still has the disadvantage that milling of the tooth flanks must take place with profile cutters and in a partial process. The invention, however, removes even this disadvantage and improves the tooth gap form so far that milling in the region of the tooth tips with grinding allowance and in the region of the tooth roots to final dimensions, can be effected in a single working operation by means of hob-type cutters. At the same time the transition of the tooth root without grinding allowance into the flank part with grinding allowance is shortened still further in order to reduce the sensitivity of the grinding operation (see above) than was the case of the tooth root of the previous example formed by equidistant lines. To this end the gap part which forms the tooth roots is formed within the pitch circle *dg* with an undercut, which commences in the region of the pitch circle and is represented as a widening of the gap. In the case of such a gap form (see the tooth gap C between the teeth 1*b* and 1*c*) the transition of the tooth root into the tooth tip appears as a relatively sharp bend, which provides a further shortening of the transition zone of the root part without grinding allowance into the tip part with grinding allowance and thus a further reduction of the harmful influence of the graduation differences. However, in the case of the undercut tooth gap form the most important point is that it can be produced with a milling cutter profile by the hobbing process, so that both the milling and the grinding of the teeth can be carried out by a rolling process.

With regard to the grinding operation the undercut tooth form also provides the advantage that it is possible to permit the grinding wheel to dip deeper into the tooth gap in the rolling grinding, which renders possible an enlargement of the wedge angle δ_3. Apart from a favourable alteration of the relation of the grinding wheel wear x to reduction of the grinding wheel diameter, the increased wedge angle has the further advantages firstly that the contact area of the grinding wheel with the tooth flank and thus the generation of crack-forming heat are reduced, and secondly that the grinding pressure occurring in the direction normal to the oblique grinding wheel faces has a larger component in the direction toward the grinding wheel spindle, so that there is a smaller transverse stressing of the grinding wheel. A further advantage of the undercut tooth flank is that the radially measured position of the bend of the tooth flank, characterising the transition of the tooth root part to the active tooth tip part, is influenced much less by small deviations in the exact grinding wheel diameter.

An advantage not mentioned hitherto but which is nevertheless of importance in limiting of the flank grinding to the tooth tip part is the increased durability of the teeth in the tooth root part. This arises due to the fact that the positive pressure stress forming, for example, during hardening is maintained in the case hardened layer on the surface of the material due to the omission of grinding.

In many practical cases of use of the adjustable gear pump the latter is always operated only in one direction of rotation and a change to the opposite direction is not readily possible if only due to variations in the internal housing shape. For the further cheapening of production the individual gear wheels of the pump then need be ground only on those tooth flanks which come into active contact with the tooth flanks of the meshing wheel.

It should also be mentioned that the invention extends to gear pumps with fixed inter-axis distance, if their teeth also have the properties of design set forth in the variable gear pump, in order to achieve a high specific delivery volume. In amplification of the features of the teeth in question the invention refers in general to those pump gears of which the height of the tooth tip part $Hk=(dk-df)/2$, contrary to that of the standard teeth (Hk=m), corresponds at least to an addendum 1.25 times the module.

WHAT WE CLAIM IS:—

1. An improvement in or modification of the gear pump arrangement claimed in claim 1 of Specification No. 882,248, wherein the gear teeth have an addendum equal to not less than 1.25×module, and wherein grind-

ing of the tooth flanks is limited to that tooth part between the pitch and addendum circles.

2. Gear pump arrangement as claimed in claim 1, wherein the root part inside the pitch circle of the gap between two adjacent teeth is formed by parallel faces spaced equidistantly from a plane radially of the gear wheel.

3. Gear pump arrangement as claimed in claim 1, wherein the root part inside the pitch circle of the gap between two adjacent teeth is formed by undercutting the tooth flanks approximately at the pitch circle.

4. Gear pump arrangement as claimed in claim 1, 2 or 3, wherein the root part of each tooth gap is milled to the final dimensions.

5. Gear pump arrangement as claimed in any one of the preceding claims, wherein only that tooth flank of each tooth which is active in operation is ground.

6. The improvement in or modification of the gear pump arrangement claimed in Specification No. 882,248 substantially as described and as shown at B or C of the accompanying drawing.

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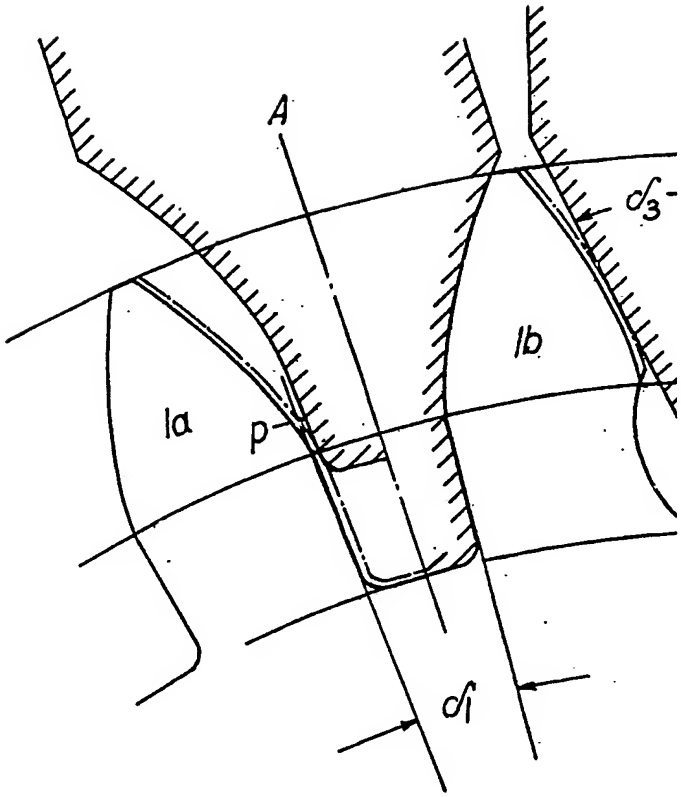

981,964 COMPLETE SPECIFICATION
1 SHEET

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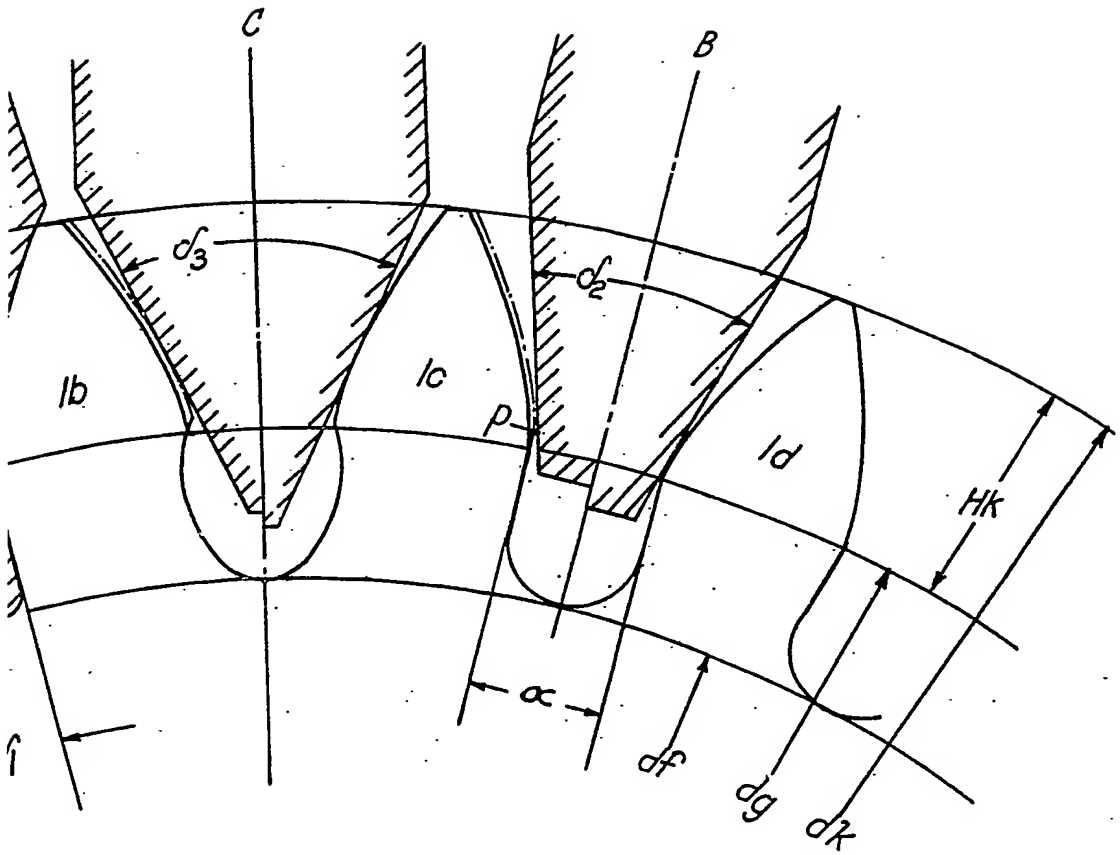

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